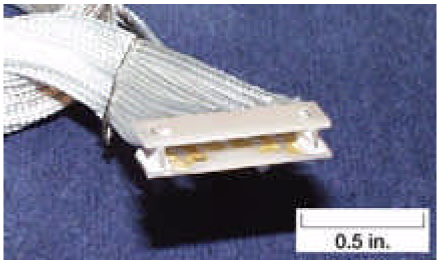
Packaging Technology Developed for High-Temperature SiC Sensors and Electronics



Prototype high-temperature electronic package (with test wires) composed of AlN substrate and Au thick-film metallization being developed for SiC sensors and electronic devices.

A ceramic- and thick-film-materials-based prototype electronic package designed for silicon carbide (SiC) high-temperature sensors and electronics has been successfully tested at 500 °C in an oxygen-containing air environment for 500 hours. This package was designed, fabricated, assembled, and electronically evaluated at the NASA Glenn Research Center at Lewis Field with an in-house-fabricated SiC semiconductor test chip.

High-temperature electronics and sensors are necessary for harsh-environment space and aeronautical applications, such as space missions to the inner solar system or the emission control electronics and sensors in aeronautical engines. Single-crystal SiC has such excellent physical and chemical material properties that SiC-based semiconductor electronics can operate at temperatures over 600 °C, which is significantly higher than the limit for Si-based semiconductor devices. SiC semiconductor chips were recently demonstrated to be operable at temperatures as high as 600 °C, but only in the probe-station environment because suitable packaging technology for sensors and electronics at temperatures of 500 °C and beyond did not exist. Thus, packaging technology for SiC-based sensors and electronics is immediately needed for both application and commercialization of high-temperature SiC sensors and electronics.

In response to this need, researchers at Glenn designed, fabricated, and assembled a prototype electronic package for high-temperature electronics, sensors, and microelectromechanical systems (MEMS) using aluminum nitride (AlN) substrate and gold (Au) thick-film materials. This prototype package successfully survived a soak test at 500 °C in air for 500 hours. Packaging components tested included thick-film high-temperature metallization, internal wire bonds, external lead bonds, and a SiC diode chip die-attachment. Each test loop, which was composed of thick-film printed wire, wire bond, and lead bond was subjected to a 50-mA direct current for 250 hours at 500 °C.

As desired, when soaked at 500 °C with or without current load, the test loops exhibited low electrical resistance (~0.3Ω). Also as expected, the electrical isolation impedance between printed wires that were not electrically joined by a wire bond remained high (>0.4GΩ) during and after the 500 °C soak. The attached SiC die (diode) showed low resistance (< 5Ω/mm^2) backside electrical contact, at both room temperature and 500 °C, through the die-attachment. These results indicate that the prototype package meets the initial design standards for low-power, long-term, high-temperature operation. This technology is being evaluated and developed further through statistical tests of each packaging element for longer lifetime and higher operation temperatures.

Find out more about this research http://www.grc.nasa.gov/WWW/sensors/.

A.Y.T. Corporation contact: Dr. Liang-Yu Chen, (216) 433–6458, Liangyu.Chen@grc.nasa.gov

Glenn contact: Dr. Jih-Fen Lei, (216) 433–3922, Jih-Fen.Lei@grc.nasa.gov

Authors: Dr. Liang-Yu Chen, Dr. Gary W. Hunter, Dr. Philip G. Neudeck, and Dr. Jih-Fen Lei

Headquarters program office: OAST, OSS

Programs/Projects: GMI, IT Base